

**LIGHTING DEVICE COMPOSED OF A THIN LIGHT EMITTING  
DIODE MODULE**

### 3 BACKGROUND OF THE INVENTION

## 4 1. Field of the Invention

5 The present invention relates to a lighting device, and more  
6 particularly to a lighting device composed of a thin light emitting diode  
7 module, which dissipates heat quickly, consumes very little energy and is  
8 very bright.

## 9 2. Description of Related Art

10       Lighting devices were designed originally to simply create light  
11      sources. However, consumers are equally concerned now with the  
12      appearance, useful life and energy consumption of lighting devices.  
13      Therefore, current lighting devices are available that save energy and meet  
14      miniaturization requirements.

15 For example, light emitting diodes (LED) have replaced early  
16 conventional tungsten and halogen bulbs in lighting devices and are used in  
17 devices such as traffic lights. Using LEDs as lighting sources has the  
18 advantages of consuming less energy consumption to save on operations cost  
19 and a longer operational life than tungsten and halogen bulbs to reduce repair  
20 and maintenance costs. Therefore, LEDs are preferred for lighting devices.  
21 Although the LEDs consume less energy, heat generated by a cluster of  
22 LEDs is not an insignificant problem in lighting devices.

With reference to Fig. 6, a conventional LED-based lightening device is composed of an LED module with a cluster or array of LED units.

1 To simplify the description, a single LED unit will be described for  
2 illustrative purposes. Each LED unit is composed of a metal substrate (100),  
3 an isolating layer (101), a circuit layer (102), an electrically conductive pad  
4 (103), a thermally conductive pad (104), an LED chip (110).

5 The metal substrate (100) has a flat top face (not numbered), and the  
6 top face is covered by the isolating layer (101). The circuit layer (102) is  
7 mounted on the isolating layer (102). A recess (not numbered) is defined in  
8 the isolating layer (101) and the circuit layer (102) to expose the metal  
9 substrate (100). The thermally conductive pad (104) is mounted on the metal  
10 substrate (100) inside the recess, and the electrically conductive pad (103) is  
11 mounted on the thermally conductive pad (104). The LED chip (110) is  
12 mounted on the electrically conductive pad (103) and connected to the circuit  
13 layer (102) by bonding wires. Additionally, a clear or colored encapsulant  
14 covers each LED unit.

15 In this conventional LED lighting device, the LED chip (110)  
16 generates light and heat when the circuit layer (102) is connected to a source  
17 of electricity. The heat passes through the electrically conductive pad (103)  
18 and the thermally conductive pad (104) into the metal substrate (100) and  
19 dissipated from exposed surfaces of the metal substrate (100).

20 However, conventional LED lighting devices have a drawback in  
21 that the lighting device is thick since the lighting device is composed of the  
22 metal substrate (100), the thermally conductive pad (104), the electrically  
23 conductive pad (103), and selectively the encapsulant formed around the  
24 chip (110). The metal substrate (100) is very thick and constitutes a design

1 limit especially when the lighting device needs to be miniaturized.  
2 Additionally, the generated heat has to be conducted through a distance (i.e.  
3 the thickness) including the substrate (100) and the pads (103, 104), which is  
4 slowly dissipated from the surface of the metal substrate (100) and causes  
5 overheating to damage other internal elements inside the lighting device.

6 The present invention provides a breakthrough in LED lighting  
7 devices by using a very thin LED module to overcome the drawbacks of the  
8 conventional LED lighting devices.

9 SUMMARY OF THE INVENTION

10 A first objective of the present invention is to provide an LED  
11 lighting device composed of a thin LED module, wherein the lighting device  
12 has a diminished size.

13 A second objective of the present invention is to provide an LED  
14 lighting device that readily dissipates heat and has a long life.

15 Further benefits and advantages of the present invention will become  
16 apparent after a careful reading of the detailed description in accordance with  
17 the drawings.

18 BRIEF DESCRIPTION OF THE DRAWINGS

19 Fig. 1 is an exploded operational side plane view of the lighting  
20 device composed of a thin LED module in accordance with the present  
21 invention, wherein the lighting device further is attached to a heat sink;

22 Figs. 2A-2C are sequential cross sectional side plan views of the thin  
23 LED module in accordance with the present invention at various stages of  
24 fabrication;

1           Figs. 3A-3B are sequential cross sectional side plan views of another  
2 embodiment of the thin LED module having a flat surface in accordance with  
3 the present invention at various stages of fabrication;

4           Fig. 4 is a top plan view of the thin LED module in accordance with  
5 the present invention;

6           Fig. 5 is a side plane view in partial section of the heat sink in Fig. 1;

7           and

8           Fig. 6 is a cross-sectional side plan view of a conventional LED  
9 lighting device in accordance with the prior art.

10          DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

11          With reference to Figs. 1 and 4, the lighting device composed of a  
12 thin LED module in accordance with the present invention comprises an  
13 LED module (10), a thermally conductive sheet (20) and a heat sink (30).

14          The LED module (10) has a top face (not numbered) and a bottom  
15 face (not numbered). The bottom face is electrically connected to conductive  
16 wires (1) and light is emitted from the top face.

17          The thermally conductive layer (20) has a flat top side and a flat  
18 bottom side, and the top side is attached to the bottom face of the LED  
19 module and also covers the conductive wires (1) on the bottom face of the  
20 LED module (10). The thermally conductive layer (20) does not conduct  
21 electricity and is selectively made of room temperature vulcanization (RTV)  
22 silicon or RTV silicon containing ceramic powder to increase the thermal  
23 conductivity of the thermally conductive layer (20). Additionally, the  
24 thermally conductive layer (20) is clamped between the LED module (10)

1 and the heat sink (30) by compressing or thermosetting combinations.

2       The heat sink (30) is attached to the bottom side of the thermally  
3 conductive layer (20).

4       With reference to Figs. 2A-2C, to facilitate the description of the thin  
5 LED module, a method used to fabricate the thin LED module is described.

6       The thin LED module (20) is fabricated by obtaining a substrate (11),  
7 forming dimples (12) on the substrate (11), forming a conductive layer (13)  
8 on the substrate (11), mounting LED chips (14) on the conductive layer (13),  
9 coating the LED chips (14) with an encapsulant layer (15), removing the  
10 substrate (11) and optionally applying an isolating layer (16).

11       The substrate (11) is made of copper, has a top face and a bottom  
12 face and serves as a supporting plate during the fabrication process.

13       The dimples (12) are formed on the top face of the substrate (11) by  
14 etching.

15       The conductive layer (13) has a top face (not numbered) and a  
16 bottom face (not numbered), is formed in multiple sections (not numbered)  
17 on the top face of the substrate (11) including the dimples (12) and is  
18 ant corrosive metal suitable for lead-tin soldering. Furthermore, gold or  
19 aluminum wires can be bonded to the conductive layer (13). The conductive  
20 layer (13) is composed optionally of copper/nickel/copper/pure nickel/pure  
21 gold, pure nickel/pure gold, pure nickel/gold/palladium, etc. Moreover, the  
22 thickness of the conductive layer (13) is preferred to be 3 µm to  
23 accommodate current desired in the circuit.

24       LED chips (14) are mounted on the conductive layer (13) to

1 electrically connect adjacent sections of the conductive layer (13). Each LED  
2 chip (14) is mounted on one section by silver paste, and a wire connects the  
3 LED chip (14) to an adjacent section on the conductive layer (13).

4 The encapsulant layer (15) is applied with a conventional packaging  
5 process to protect the LED chips (14) and is made of transparent material.  
6 Since conventional packaging processes are well-known, further description  
7 of appropriate packaging processes is omitted.

8 The substrate (11) is removed by etching from the bottom face of the  
9 conductive layer (13). With the substrate (11) removed, the conductive layer  
10 (13) at the dimples (12) protrude and can connect to wires. Optionally, parts  
11 of the substrate (11) are retained and serve as a lead-frame (11') at opposite  
12 edges of individual LED modules for testing or for bending to be gull-wing  
13 leads. Then, the isolating layer (16) is formed on the bottom face of the  
14 conductive layer (13) between adjacent protruding dimples (12) and covers  
15 exposed sections of the encapsulant layer (15). The isolating layer (16) is  
16 white and reflects light emitted from the LED chips (14).

17 With reference to Figs. 3A and 3B, another embodiment of the thin  
18 LED module is essentially the same as that previously described except no  
19 dimples are formed in the substrate (11a) or the conductive layer (13a).

20 Removing the substrate (11, 11a) causes the thin LED module to be  
21 much thinner than the conventional LED module. Therefore, the LED  
22 module having no substrate is diminished in thickness but also has multiple  
23 LEDs chips (14) densely arranged in an array.

24 With reference to Fig. 5, the heat sink is also improved in the present

1 invention. The heat sink (30) has an outer surface area (not numbered) and  
2 comprises a sealed chamber (31), a vaporable liquid (33) and multiple fins  
3 (32). The sealed chamber (31) has an inner face (not numbered), an outer  
4 face (not numbered) and an inside surface (not numbered). The inner face of  
5 the heat sink (30) attaches to the thermally conductive layer (20) to absorb  
6 heat from the thin LED module. The vaporable liquid (33) is held inside the  
7 chamber (31) near the inner face to absorb heat from the LED module (10).  
8 The fins (32) respectively have a proximal end (not numbered) and a distal  
9 end (not numbered). The proximal ends of the fins (32) are attached to the  
10 outer face of the chamber (31) so the fins (32) increase the outer surface area  
11 of the heat sink (31). The heat sink (30) works by absorbing heat from the  
12 LED module (10) through the inner face. The absorbed heat causes the  
13 vaporable liquid (33) inside the sealed chamber (31) to vaporize and conduct  
14 heat more readily to the outer face of the sealed chamber (31). Then heat in  
15 the outer face is conducted heat to the fins (32) and dissipated to the  
16 environment. Since the vaporable liquid (33) transfers heat to the outer face  
17 of the chamber (31) and the fins (32) in a gaseous state, the heat is evenly  
18 transferred to the fins (32) so the heat dissipated from the fins (32) is  
19 dissipated at or near peak efficiency. Furthermore, the vaporable liquid (33)  
20 condenses quickly when heat is transferred to the outer face and the fins (32).

21 Several advantages of the lighting device composed of a thin LED  
22 module are listed as follow:

23 1. Since the LED module (10) has no substrate (11), the lighting  
24 device is significantly thinner. Thereby, the lighting device can be minimized.

1           2. The lighting device is stable and durable because the heat sink  
2       dissipates generated heat rapidly to avoid malfunctions caused from  
3       overheating.

4           3. The lighting device has excellent brightness since the LED chips  
5       (14) can be densely mounted in a thin LED module (10).

6           Although the invention has been explained in relation to its preferred  
7       embodiment, many other possible modifications and variations can be made  
8       without departing from the spirit and scope of the invention as hereinafter  
9       claimed.